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The National Systems of Innovation Approach and Innovation by SMEs

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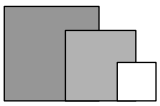

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Abstract

The National Systems of Innovation (NSI) concept came into being in the late 1970s. Since 1992 the approach has been adopted surprisingly fast by academia as well as by national governments and international organisations such as the OECD and European Union. The NSI approach helps to understand how innovation evolves and what the elements and framework conditions are that determine and affect innovation and economic development. It offers a 'richer picture' of reality compared to mainstream theories on innovation. The NSI approach also offers policy makers the potential to derive more appropriate leads for government intervention in innovation. The alternative view on innovation in NSI literature has opened the way for the identification of new rationales for government intervention, the so-called system failures. This study operationalises the NSI conceptual framework for SMEs. It drafts characteristics of an SME NSI and the system failures therein. The study also derives a number of leads for SME innovation policy.

Keywords: national systems of innovation; market and system failures; SME-specific innovation policies

1 Introduction

Aim of the study

The National Systems of Innovation (NSI) approach is a young but successful approach to help to understand how innovation and interactive learning evolve in national economies and how they propel economic prosperity and international competitiveness. The NSI approach has been embraced by policy makers all around the world, because this approach offers them the potential to derive more appropriate leads for innovation policy. In the Netherlands too, the drafting of innovation policy is increasingly based on the NSI concept.[1]

The main aim of this study is to add to the understanding of the NSI approach. The research questions addressed in this study include: What are the main concepts, value added and shortcomings of the approach? And: How does the NSI approach offer policy makers the potential to derive more appropriate leads for innovation policy?

One aspect of the NSI approach is that it does not distinguish between individual companies or groups of companies in the system. The NSI literature treats companies as identical organisations. In this study we apply the conceptual framework of the NSI approach to innovation by small and medium-sized enterprises (SMEs). SMEs are an important source of employment and growth in the Netherlands. In this study we describe innovation by SMEs using the conceptual framework of the NSI approach. By doing so we actually draft characteristics of an SME NSI, including the system failures that occur in this SME NSI. As such, the study should provide a grip for the improvement of the innovation system in The Netherlands and the role of SMEs in particular.

Structure of the report

This report is organised as follows. In chapter 2 we discuss the NSI approach (its history, theoretical roots and main concepts) and assess the value added and the shortcomings of the approach. In chapter 3 we illustrate how the NSI approach can offer policy makers the potential to derive more appropriate leads for innovation policy. This chapter also presents a newly configured framework of system failures. Next we apply the conceptual framework presented in chapters 2 and 3 to innovation by SMEs. In chapter 4 we draft a characterisation of an SME NSI and the system failures that occur (or may occur) in it. Chapter 5 presents the conclusions from the analysis in this study and formulates suggestions for further research.

[1] The Dutch Ministry of Economic Affairs uses the term Dynamic Systems of Innovation (DIS) to take account of the fact that, for a small and open country like the Netherlands, the international dimension has an increasing impact on the innovation system, partly at the expense of the national character.

2 NSI: history, roots and key concepts

2.1 Introduction

The NSI concept came into being in the late 1970s when members of the IKE group at Aalborg University, Denmark, began to integrate a French structuralist approach to national systems of production in the Anglo-Saxon tradition in innovation studies, in order to explain international competitiveness. The concept gained ground after the publication 'National System of Innovation - Towards a theory of innovation and interactive learning' by Lundvall and others in 1992. Other names that are associated with the birth and growth of the NSI approach are Freeman (1987), Nelson (1993) and Carlsson (1997).

The notion inherent in the NSI approach of innovation as an interactive and socially embedded process entailed a novelty in mainstream theories on international competitiveness and economic growth. In classical growth models (e.g. Solow, 1956 and 1957) innovation was considered as exogenous to the economy and could harm the economy's equilibrium. These models did not explain innovation. In new growth models (e.g. Romer 1990, Grossman and Helpman 1991, Aghion and Howitt 1990) innovation is endogenous. Yet the concept of innovation in new growth models is completely different from the NSI approach. With the NSI approach thinking on innovation has moved away from the linear approach, which assumed that efforts in research and development cause innovation and commercialisation and subsequently better economic performance. Innovation is an interactive process in which its key actors, e.g. firms, interact with a manifold of other actors in their environment (research organisations, customers, regulators), influencing this innovation process. Innovation is therefore understood as a very complex process with intricate causal links (Technopolis 2001).

Since 1992 the approach has been adopted surprisingly fast by academia (leading e.g. to a special issue on NSI in the Cambridge Journal of Economics in 1995) as well as by national governments and international organisations such as the OECD and European Union.

2.2 Theoretical roots and basic assumptions

The NSI approach has its roots in theories of innovation, interactive learning and in evolutionary economics (see e.g. Dosi 1988). Basic beliefs are adopted from the innovation and interactive learning theories, such as the belief that firms do not innovate in isolation, but are in constant interaction with other actors in the system, profit and non-profit actors (e.g. universities, public research laboratories). Their innovation activities are hence strongly affected by these interactions. Furthermore, an organisation's possibility and inclination to innovate will be affected by legal conditions, rules and norms. The influences of these theories can most explicitly be found in the NSI approach as used by Edquist, Lundvall and others (see below). From these theories on innovation and learning, the two basic assumptions (Lundvall 1992:1) that underlie the NSI approach are derived:

– First, it is assumed that the most fundamental resource in the modern economy is knowledge and, accordingly, that the most important process is learning. The fact that this resource differs in crucial respect from the traditional economic resources

makes standard economics less relevant and motivates the development of an alternative paradigm.
– Second, it is assumed that learning is predominantly interactive and therefore a socially embedded process, which cannot be understood without taking into account its institutional and cultural context. Because of this the development of nation states is considered a crucial process in understanding the acceleration of learning and innovation which propelled industrialisation in the 19th century. The process of internationalisation and globalisation now challenges this role of the nation state.

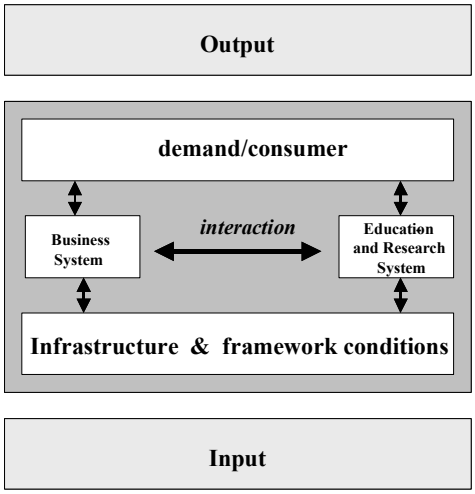
Whereas the theories of innovation and learning focus more on the meso-level, with the interaction between actors in the economic system as its level of analysis, the elements taken from evolutionary theories focus more on the macro level. Concepts such as reproduction, creation of novelty and variety, and selection play an essential role (see e.g. Nelson 1987, Nelson and Winter 1977). Crucial to the evolutionary approach is that a system is in constant flux and that it does not reach equilibrium. This understanding has been adopted in the NSI approach with its emphasis on constant transition. In this view, innovation is aimed at producing products and processes that better fit their constantly changing environments and are selected and will be re-selected again by that environment. Hence, neither products nor the economic system ever reach a perfect end-state (equilibrium). For government policy this implies that policy measures should not be aimed at achieving a set goal, but should rather aim to facilitate the processes of novelty creation, variety, adaptation and selection.

2.3 Key concepts

The main argument for introducing the NSI approach is to provide an alternative for the well established neo-classical paradigm that focuses on scarcity, allocation and exchange in a static context. The NSI concept offers an alternative that presents a much more holistic and dynamic view on economic development. An important advantage of the NSI approach is that it pays attention to *how* R&D might lead to innovation, but also how innovation might be triggered by the market or producer-user relationships for example. This 'how' question can be answered only by looking at all elements of the system that influence the innovation process. These mechanisms include efficient knowledge transfer between R&D institutes and companies, inter-firm cooperation in networks, and efficient intellectual property rights (IPR) regimes. The NSI approach acknowledges that innovation is an interactive, non-linear process in which actors, e.g. firms, interact with a manifold of other organisations (e.g. research institutes, customers, authorities, financial organisations). These interactions are governed by institutions (e.g. IPR, regulations, culture). This complex process, characterised by reciprocity and feedback mechanisms, determines the success of innovation (e.g. Freeman 1987 and 1988, Lundvall 1992, Nelson 1993, Edquist 1997).

Figure 2.1 gives an example of a schematic representation of a NSI.

Figure 2.1 Schematic representation of an NSI



Source: Ministry of Economic Affairs.

Although the NSI approach has been highly successful judging from its fast diffusion and although it is considered promising, none of the protagonists considers the approach to be a formally established theory (Edquist 1997).[1] The definitions of the key concepts and the boundaries of the NSI have not (yet) been defined unambiguously:

- **Innovation**: Innovation can be defined in various ways, ranging from incremental to radical innovation, and from product to process innovations. Definitions may vary from very broad to narrow, but all authors focus on technological innovation and are interested in organisational and institutional change.
- **National**: Although most authors discuss the accurateness of a national approach in the light of increasing internationalisation and globalisation, they make a strong plea for a national focus since the nation state is typically the arena in which cultures and institutions are rooted. Furthermore, the national focus is helpful for governments since this is the specific context in which a national government intervenes. However, the NSI concept may just as well be applied in a supranational or regional context, or in a sector or industry (technology focus), or in a combination of both.[2]
- **System**: Essential for the understanding of innovation and learning is that the whole system is considered. A general definition of a system is: 'complexes of elements or components that mutually condition and constrain one another, so that the whole complex works together, with some reasonably clearly defined overall function' (Fleck 1992:5). Where the boundaries of this system lie, is left open to be able to include all elements that are relevant for example to analyse a system or design policy (Lundvall 1992, Edquist 1997). Systems are partially consciously built (e.g. by the state) and partially spontaneously evolved.

As a result of the 'conceptual ambiguities' (Van Tulder et al. 2000) the contributions to the literature on NSI are quite diverse. The technological systems approach (Carlsson

[1] It is for this reason that throughout this report we refer to the NSI *approach* as opposed to the NSI *theory*.

[2] The Dutch Ministry of Economic Affairs uses the term Dynamic Systems of Innovation (DIS) to take account of the fact that, for a small and open country like the Netherlands, the international dimension has an increasing impact on the innovation system, partly at the expense of the national character.

1995) emphasises that innovation systems differ for various technological fields and hence the approach should be sectoral rather than national. Within technological innovation the focus can be on a certain type of technology or a technological regime (Malerba and Orsenigo 1990, 1993 and 1994) or a type of innovation (e.g. national system of biotechnology innovation in Bartholomew (1997). Saxenian (1994) can be seen as a good example of the regional approach. She studied 'regional industrial systems' such as Silicon Valley, and Route 128. Close to this approach are the studies of 'industrial districts', which have gained ground since Marshall introduced the concept (see e.g. Piore and Sabel 1984, Pyke, Becattini and Sengenberger 1992).

2.4 Value added and shortcomings of the NSI approach

The conceptual ambiguities and the subsequent diversity in the literature notwithstanding, the NSI approach has two important advantages. First of all the NSI approach helps to understand how innovation evolves and what are the elements and framework conditions that determine and affect innovation and economic development. It offers a 'richer picture' of reality compared to mainstream growth models. Second (and related to the first advantage), the NSI approach offers policy makers the potential to derive more appropriate leads for government intervention in innovation. This issue will be further elaborated in the next chapter.

A downside of the NSI approach is that the theoretical framework it offers, is (necessarily) rather abstract. The conceptual framework of the NSI approach offers only a view of the elements and framework conditions that determine and affect innovation processes *in general* (see e.g. Figure 2.1). In reality there are numerous innovation processes. Each has its own specific (sub-)system of organisations, interactions and institutions, with its own specific causal links, determining and affecting it. To obtain a more specific grasp of the characteristics of a NSI the conceptual framework has to be 'operationalised' at appropriate levels. Hence the conceptual framework of the NSI approach can be used only as a 'focusing device' (Lundvall 1992).

In the present research project the conceptual framework of the NSI approach will be operationalised for innovation by SMEs. This is elaborated in chapter 4.

3 NSI and innovation policy[1]

3.1 Introduction

The NSI approach offers policy makers the potential to derive more appropriate leads for interventions than the neo-classical market imperfections approach could. Although it is recognised that the market imperfection framework is powerful under some circumstances, it is claimed that the market failure approach is not able to capture the key elements of technological progress (OECD 1992) and that it is particularly weak in identifying where subsidies should go, i.e. which organisations should be supported (Edquist et al. 1998). It thus has limits as a rationale and guide for innovation policy design (Hauknes and Nordgren 1999).

The market failure framework proposes a rather linear innovation process in which R&D, through the development of new products and processes automatically leads to successful commercialisation (innovation). In this interpretation innovation policy would consist mainly of generic policy measures aimed at stimulating R&D. The NSI approach has the potential to offer a 'richer picture' of reality, thereby overcoming the disadvantages of the neo-classical approach. It does take into account the institutional context in which actors operate and acknowledges that not only markets play a role in the economy, but so does the public sector (and thus non-market factors).

By paying more attention to the basic mechanisms that shape the system, instead of viewing the system as a market with anonymous players, the NSI approach does carry the potential to give leads on effective government intervention when such intervention is warranted. By identifying the interactions between actors and institutions, the NSI approach uncovers the actors and mechanisms that lead to successful innovation that were left untouched by the market imperfections approach. Thereby it offers the opportunity to better identify where public support should go (which actors to address, for example) when innovation is hampered, and is more helpful for policy makers from a practical and specific point of view (Edquist et al. 1998).

By introducing this alternative view on innovation, the NSI literature has opened the way for the identification of new rationales for intervention, the so-called system failures. This will be addressed in this chapter.

3.2 System failures

The basic conceptual underpinnings of the NSI approach are, first, that innovation does not take place in isolation. ***Interaction*** is central to the process of innovation, i.e. interaction between actors (firms, universities, intermediaries, etc.) within the framework of existing institutional rules (laws, norms, technical standards etc.). Central to the concept of interaction are both cooperation and interactive learning (Lundvall 1992). A second assumption is that ***institutions*** are crucial to economic behaviour and performance (Smith 1997): legally or customarily institutions, such as regulation, law, norms and culture, form the 'rules of the game' or 'the codes of conduct' that evolve because of their

[1] This chapter draws on an article soon to be published in *Technovation*.

function in reducing uncertainty in the economic system. Third, ***evolutionary processes***[1], which in a process of generating variety, selecting across that variety to produce patterns of change and producing feedback from the selection process to variation creation (Hauknes and Nordgren 1999), create novelty by a process of constant interaction, or transmission, among heterogeneous actors in a population (Smith 1999). The creation of such novelty is necessary to maintain the diversity that makes selection possible (Nelson 1995; McKelvey 1997). Systemic imperfections can occur in all these basic elements if the combination of mechanisms is not functioning efficiently. If so, learning and innovation by actors may be blocked slowing down the innovation system as a whole.

Various authors, such as Carlsson and Jacobson (1997), Smith (1997), Malerba (1997), Johnson and Gregersen (1994) and Edquist et al. (1998) look carefully at these systemic imperfections, with the following list of system imperfections as result:

- **Infrastructure failures** (Smith 1999, Edquist et al. 1998) being the physical infrastructure that actors need to function (such as IT, telecom and roads) and the science and technology infrastructure.
- **Transition failures** (Smith 1999) being the inability of firms to adapt to new technological developments.
- **Lock-in/path dependency failures** (Smith 1999) being the inability of complete (social) systems to adapt to new technological paradigms. NB: Edquist et al. (1998) address the same failure but do not distinguish so strictly between transition and lock-in failure.
- **Hard institutional failures** being failures in the framework of regulation and the general legal system (Smith 1999). These institutions are specifically created or designed (Edquist et al. 1998) for which reason Johnson and Gregersen (1994) refer to them as formal institutions.
- **Soft institutional failures** being failures in the social institutions such as political culture and social values (Smith 1999, Carlsson and Jacobson 1997). These institutions evolve spontaneously (Edquist et al. 1998) for which reason Johnson and Gregersen (1994) refer to them as informal institutions.
- **Strong network failures** (Carlsson and Jacobson 1997) being the 'blindness' that evolves if actors have close links and as a result miss out on outside new developments.
- **Weak network failures** (Carlsson and Jacobson 1997) being the lack of linkages between actors as a result of which insufficient use is made of complementarities, interactive learning, and creating new ideas. Malerba (1997) refers to the same phenomenon as dynamic complementarities failure.
- **Capability failures**: Smith (1999) and Malerba (1997) refer to the phenomenon that firms, especially small firms, may lack the capabilities to learn rapidly and effectively and may hence be locked into existing technologies, thus being unable to jump to the new technologies.

[1] Evolutionary processes depend on the following premises:
- Bounded rationality of agents - Rather than optimising a mathematical function, firms use simple rules of thumb to make investment decisions.
- Diversity - Rules of thumb differ from one firm to another.
- Asymmetric information is a condition for successful innovation rather than that it should be presented as being a market failure. Without asymmetry there can neither be novelty nor variety (Hauknes and Nordgren 1998).
- Path dependence - Technological progress (learning) is cumulative - the ability of firms to innovate is dependent on what they have been doing in the past (Dosi 1988).

Whereas the above systemic failures do give a good insight into the types of issues that policy makers might address in their innovation systems, the still loosely configured framework does not render a structured approach. In the next sections we shall solve this problem. Our effort should not be considered as an attempt to 'model' the still ambiguous NSI approach, but rather as an attempt to design a practical framework that enables clearer and mutually exclusive definitions of systemic failures since, in our view, the current approach still under-exploits its potential to provide practical guidelines and/or rationales for innovation policy. We shall therefore discuss the systemic failures in more detail to be able to arrive at a clear-cut categorisation of failures that can serve as a rationale for innovation policy design.

3.3 Reframing the system failures framework

In the literature helpful leads were found on how more clarity could be achieved in the system failure scheme. Most authors acknowledge that much of the confusion in the SI approach results from its terminology. This, because the term 'institution' is often used to mean 'organisation' in common usage, whereas economists in the institutionalist tradition have a more specific usage-institutions correspond to rules, while organisations are players (Bryant, 1998: p. 71). We found this distinction between rules and players (a point also made by Edquist et al. (1998) and North (1991)) to be a crucial distinction to enable the definition of mutually exclusive system failures and the design of an SI-approach-based policy framework. If the distinction between rules and players is translated into the policy arena, one can define the players/actors as the policy makers, firms, universities, etc. that actually 'act' to make policy objectives happen. The rules/institutions can be translated into the outcomes of their actions, e.g. legal offices write law (hard/formal institutions), companies together form a cooperative culture (soft institutions), universities and firms form R&D alliances (interaction), etc. It is mainly in the 'rules' category that system failures occur. IPR regimes may be too strict or cultures too risk averse to enable innovation (institutional failure), or firms may fail to interact properly (network failure). Only if essential organisations are lacking in the system, do system failures occur on the 'actor's side'. For example, if regulatory bodies are absent, firms will miss these laws to safeguard their intellectual property rights in the innovation process. Other examples of missing actors might be venture capitalists, insufficient innovative buyers (lack of lead users), or the absence of research institutes for applied knowledge. This lack will be referred to as 'missing actors' and will not be regarded as systemic failures on the 'rules' side' although the actors by being absent can cause systemic failure (Edquist, 2001).

By keeping a clear distinction between actors and the rules which are most related to the system failures, the system failure framework can be reorganised in a way that the definitions of failures exclude one another. This categorisation is not claimed to be 'the one solution' that will set the standard for future discussions on the SI approach and system failures. It is intended to become a practical tool for both researchers and policy makers to:

- analyse where system failures occur, e.g. what failure occurs, what actors - or interactions between them - are hindered,
- validate system-based policy choices what actors or failures to focus on,
- evaluate current government policies, e.g. do they address the right failures/actors or are there other or more important ones that form the bottleneck in the system?

The newly configured framework is presented in figure 3.1 and the rationales for restructuring the framework in this way will be dealt with briefly later.

Figure 3.1 The system-based innovation policy framework

Actors (missing actors)	**Demand** •Consumers •Large buyers	**Companies** •Large firms •MNCs •SMEs •Start-ups	**Knowledge institutes** •Universities •Technology institutes	**'Third parties'** •Banks, VCs •Intermediaries, consultants •Sector organisations, employers
Infrastructural failure: ICT, roads, railroads, telecom, ..				
Institutional failure: • Hard: laws, regulations, …				
• Soft: norms, values, …				
Interaction failure • Weak network failure				
• Strong network failure				
Capabilities failure				

Source: Klein Woolthuis, Lankhuizen and Gilsink, 2004

The four categories presented above are structured in a way that allows us to distinguish between

– **actors**, i.e. the customers, firms, policy departments, research institutes, consultants etc. that act and thereby co-create products, technologies but also the institutional framework in which they function. Because of the aim of our paper, we place policy makers in a central role and see the others as actors with which they can interact in order to design, implement and evaluate innovation policies.
– **rules**/system failures, i.e. the conditions that influence the functioning of individual actors, but also the system as a whole.

Using this distinction, the system failures are positioned on the left hand side of the diagram whereas the actors that can cause, and thus also solve, these failures, are placed at the top. This distinction between actors and failures also makes it possible to make a clearer distinction between cause and effect in terms of system functioning and outcomes. For instance, weak network failure may occur when companies do not interact efficiently; this may be a lack of cooperation with market parties or with technologically complementary firms or, for example, with the knowledge infrastructure (the actors). Furthermore, the attentive reader will notice that in the framework no use is made of lock-in and path-dependency whereas these are clearly central concepts in the systems approach. This is because these phenomena are considered a result rather than a cause of systemic failure. Lock-in can, for example, be the result of too few weak ties to bridge structural holes (strong network failure), lack of complementary cooperative relationships (weak network failure) or a simple lack of technological and organisational capabilities within the firms themselves (capability failure). Lock-in therefore refers to a complex composition of causes: it does not concern only the shift to a new single technology but also acknowledges the interconnection of that technology with its social and economic environment.

'This means that technological alternatives must not only compete with components of an existing technology, but with the overall system in which it is embedded. Technological regimes or paradigms persist because they are a complex of scientific knowledge, engineering practices, process technologies, infrastructure, product characteristics, skills and procedures which make up the totality of a technology and which are exceptionally difficult to change in their entirety.' (Smith, 1999:44).

Since innovation policy is generally aimed at stimulating technological progress and lock-in can be considered as stopping progress at the systems level (and as a result of the failures mentioned in the scheme above), system-based innovation policy could be redefined as the process of identifying the causes of lock-in and eliminating these bottlenecks so enabling innovation and economic progress at both the firm and system level. The uncovering of causes seems a good way forward to identify the (mix of) objects (actors/failures) policy makers should focus on in this process.

3.4 System failures in the system-based innovation policy framework

Based on our literature review and the reframing of the system failure framework, we have come to the following conceptualisation of the system failures. The categorisation aims to provide a detailed description of causes, thereby making it possible to analyse where bottlenecks exist and to design policy measures accordingly.

3.4.1 *Infrastructure failures*

Issues regarding the physical infrastructure in relation to innovation have received relatively limited attention from innovation scholars. However, for companies to succeed, they need a reliable infrastructure to enable their everyday operations and support their long-term developments. The knowledge infrastructure and a high-quality ICT-infrastructure in particular are emphasised in the field of innovation. Smith (1999) and Edquist et al. (1998), differentiate between the following elements:

– Communication and energy: high-speed ICT infrastructure, broadband, telephone, energy supply etc.
– Science-technology infrastructures: presence of a knowledge institutes such as universities, publicly supported technical institutes, schools etc[1].

We would like to emphasis the importance of the additional infrastructures of accommodation and transport. Fluid roads, reliable railroads, adequate offices, laboratory space, science parks, etc. form a basic condition for an economy to flourish.

In general, such forms of infrastructures are characterised by their very large scale, indivisibility, and a very long time horizon of operation. Therefore, it is very unlikely that they will produce adequate returns (ROI) for private parties to invest in such infrastructures (Smith, 1999). This makes clear why government has a responsibility to address such infrastructure needs and prevent failures from occurring.

3.4.2 *Institutional failures*

All authors distinguish institutional failures. This should come as no surprise, since institutions form a key factor in systems theory that envisages the institutional context as a defining and structuring element in the system. The authors do not agree though on how to frame and define the different forms of failure. Whereas Carlsson and Jacobson (1997) refer to hard and soft institutional failure, Edquist et al. (1998) refer to consciously created versus spontaneously evolved institutions, and Johnson and Gregersen

[1] Smith (1999) not only speaks of the presence of such infrastructure but also draws attention to the interaction with these infrastructures. In this paper a strict distinction is made between the actors (knowledge institutes, companies etc.) and the systemic failures that hinder or support these actors. In this manner of modelling the knowledge institute is considered an actor, whereas the infrastructure it provides (knowledge, possibilities for knowledge transfer, or interaction) is framed as a system characteristic (or failure).

(1994) distinguish between formal and informal institutions. Although named differently, there is a clear consensus that there are 'hard' institutions, being the formal, written, consciously created institutions, and the 'soft' institutions that are informal, have often evolved spontaneously and may be the implicit 'rules of the game' (North 1991). Both may regulate economic behaviour and interaction, and can thereby stimulate or hinder innovation. Taken together these institutions are conceptualised as the selection environment in which firms, knowledge institutes as well as the government itself are embedded. As a result, we can distinguish between hard institutional failures and soft institutional failures. We shall elaborate on these failures below.

Hard institutional failures

Hard institutional failures refer to the formal institutional mechanisms that may hinder innovation. These may be part of the framework of regulation, which consists of (Smith, 1999):

– technical standards, labour law, risk management rules, health and safety regulations etc.
– the legal system relating to contracts, employment, IPR within which the actors (not only firms, but also knowledge institutes and, for example, the government) operate.

These laws and regulations are often at national level, but increasingly also at supranational level (EU). Examples are international anti-trust regulations, accounting rules, and health and safety regulations. This framework also includes the legal system relating to contracts and employment, IPR etc. Particularly important for innovation are IPR, since they enable actors to appropriate the benefits of innovation, and the system of corporate governance (Edquist et al., 1998). For innovation to be successful the system of corporate governance should allow the management to invest in tangible and intangible assets upon which innovation depends. Short term planning horizons, risk aversion and strong emphasis on short pay back periods for investments (driven by the 'share holder's value' paradigm), will be likely to hinder successful innovation. Because of the importance of IPR, Malerba (1997) refers to hard institutional failures as the appropriatability conditions: A too stringent appropriatability regime may greatly limit the diffusion of advanced technological knowledge and eventually block the development of differentiated technological capabilities within an industry. This is defined as the appropriability trap.

Soft institutional failures

Whereas the hard institutional failures refer to the formal, written laws and regulations, the soft institutional failures find their source in the wider context of political culture and social values, which shapes public policy objectives, the macroeconomic policy environment (Smith 1999) and the way 'business is done'. These soft or informal institutional failures include social norms and values, culture, the willingness to share resources with other actors (Saxenian 1994), the entrepreneurial spirit within an organisations, industries, regions or countries (Carlson 1997), tendencies to trust (Fukuyama 1995), risk aversion etc. These institutions form the implicit rules of the game that can stimulate or hinder innovation.

3.4.3 *Interaction failure*

A basic premise of the systems approaches is that markets characterised by atomic, one-shot buyers and sellers do not actually exist. Rather, market relationships 'persist through time and involve inter-firm cooperation in the development and design of

products' (Smith 1999: 21). Hence the links, interactions and cooperative relationships between the actors in the NIS, are a central element to the analysis. These interactions not only involve relationships with other firms, they also involve the interaction with, for example, government, public knowledge institutes, and third parties such as specialised consultants. Interaction failures can evolve in two ways: there can either be too much or too little interaction, strangely enough leading to the same sort of systemic failure.

Carlsson and Jacobsson (1997) distinguishes between weak and strong network failures, that arise in situations in which interaction is too weak (little of no interaction) or too strong (too much interaction. Malerba (1997) refers to situations of weak network failure as dynamic complementarities failure. Both strong and weak network failure can hamper innovation. In the elaboration below, we have added insights from the fields of inter-organisational relationships, strategic alliances and sociology.

Strong network failure

Intensive cooperation between actors can be very productive as a source of synergy, complementary know-how, creative problem solving, capacity sharing etc. (e.g. Rothwell 1989 and 1992, Contractor and Lorange 1988) However, strong cooperative relationships among an established group of actors also implies risks. Carlsson and Jacobsson (1997) describes the situation of strong network failure as one in which individual actors are guided by other network actors in the 'wrong direction' and consequently fail to supply each other with the required knowledge. This is caused by a lack of information exchanges with actors who perform a bridging role, i.e. that tap into new knowledge, question existing routines etc. This may potentially block renewal from outside. We add the following causes for strong network failure:

1 **Myopia** due to internal orientation: If the network or cooperative relationships are long established and trust relationships and habituation have been formed, the relationships can become characterised by a certain degree of closure (Bogenrieder and Nooteboom 2002). The group will be reluctant to exit the group, or let new entrants in. Within the group, 'group thinking' may lead to myopia and inertia (Nooteboom 2002), i.e. parties will focus mainly on themselves and on what they do well. As a result, insufficient attention is paid to developments outside, and the firms may be locked into existing (technological) trajectories. Successful networks (hot spots) may then well develop into unsuccessful ones (blind spots) due to their ignorance of relevant developments outside (Pouder and St. John 1996). In the literature this is also referred to as over-embeddedness (Granovetter 1985) and social liability (Leenders & Gabbay 1999).
2 **Lack of weak ties**: The strong tie argument was initially placed on the agenda by Granovetter (1983). He discussed the value of weak ties in breaking through a too strong internal orientation. Weak ties are the 'bridges' to relative strangers from e.g. different industries, and different educational or cultural backgrounds. Because of their relative distance to the 'inner circle', they have not, for example, become part of the group-thinking as described above. The work of Granovetter (1983) and Burt (1987) emphasizes the importance of these relationships because these form the weak links to new knowledge and impulses or span the structural holes (Burt 1987) of knowledge that the individual firm lacks. They plea for a portfolio of external linkages with external parties to keep up to date with new developments and keep a tap into new knowledge, skills and resources.
3 **Dependence on dominant partners**: Whereas the two points above refer merely to the internal versus external focus of actors, dependence refers to the ability of partners to switch to alternative partners or ways of doing things. Actors may be 'locked into' their relationships due to asset specifity, switching costs or due to a

lack of alternative partners in high tech or highly monopolised markets, for example (Williamson 1985).

Weak network failure

Effective innovation takes place more and more between complementary technologies and actors. When the connectivity among these elements is poor, fruitful cycles of learning and innovation may be hindered. Carlsson and Jacobsson (1997) refer to this as weak network failures. This is consistent with Malerba's (1997) concept of dynamic complementarity failure. Complementarity may concern knowledge, skills, know how and capacity. As a result of weak network failures possibilities for interactive learning and innovation are under-utilised and firms may fail to adapt to new technological developments. Moreover, if organisations in a system interact poorly, this may lead to a lack of shared vision of future technology developments, which in turn might hinder the coordination of research efforts and investment (Carlsson and Jacobson 1997).

Both strong and weak network failures can in their own manner hinder successful innovation.

3.4.4 *Capabilities failure*

Whereas strong and weak network failures can, for example, lead to lock-in, the lack of effective and efficient interaction is certainly not the only cause. Companies can also simply lack the competences, capacity, or resources. We refer to this failure as capabilities failure. Central to the argument is that firms are unable to make the leap from an old to a new technology or paradigm. To be able to make such leap, firms need capabilities such as flexibility, learning potential, and resources to adapt to new technologies and market demands and be able to survive. Even if they can tap into these resources through inter-firm relationships (interaction), they will only gain access to these resources if they have something to offer in return. Therefore the individual strength and development potential of a firm is of crucial importance. Smith (1999) signalled problems with regard to this when he observed that firms often have problems adapting to new technologies and markets. This is because 'Firms almost always concentrate on what they know best: they focus on products and technologies where they have experience and skills' (Smith 1999: 43). This specialised focus enables them to 'do their thing right', but can seriously hinder the firm's development if the required capabilities to adapt to new technologies, lie outside a company's existing capabilities. This is even more the case if a shift is needed to a complete new technological paradigm. This will entail adaptation to completely new generic technologies, requiring capabilities (which are usually not only technical but also organisational) that lie outside the existing structure of capabilities. This might prove difficult, especially for SMEs, with limited resources and staff. Smith (1999) labels this type of failure 'transition failure'. Malerba (1997) discusses the same phenomenon under the heading of 'learning failure': firms or industries may be prevented from learning rapidly and effectively which might lead to lock-in into existing (technological) trajectories.

3.5 Using the system-based innovation policy framework

The systemic failures as presented cannot be addressed directly, or by one actor alone. If policy makers want to use the framework, they will have to address (groups of) actors to make changes in the innovation system possible. By using the framework as a tool for analysis, policy makers can identify 1) where systemic failures occur (e.g. a lack of entrepreneurial spirit hinders innovation) and 2) which actors should be addressed to

make change possible (e.g. promote an entrepreneurial spirit at knowledge institutes, provide venture capital). Most problems in the innovation system will not be uni-dimensional but consist of a complex mixture of causes and effects, and involve several actors. By using the framework, priorities can be given to the most stringent obstacles for innovation and thus also serve as a guideline to implement innovation policy. Lastly, the framework can be used as a tool for the evaluation of (already implemented) policy programmes. By first analysing where the major bottlenecks were located in the innovation system, and then evaluating what the policy actions focused on, it is possible to evaluate the extent to which the policy measures addressed the right systemic failures and actors. One can then link the success of the policy measures to the 'fit' between the system-based framework analysis and actual measures to find whether the system-based framework can explain 'ex-post' whether the approach taken was the most suitable one. In short, this framework provides value added for policy makers in three distinct ways:

– It indicates those elements of an innovation system in which failures can occur and as such forms a basis for policy choices as to what actors or failures to focus on.
– It points to the fact that policy measures should differ for distinct types of systemic failure.
– It enables the evaluation of such policies: to answer the question whether the right failures have been addressed and how the effectiveness of policy differs per type of failure.

To be able to use the framework, policy makers will have to define the field in which they wish to use it. If applied to the entire national innovation system, the design and implementation of policies will prove too complex. Instead, it is recommended that the system approach should be applied to sectors, clusters or sub-categories of actors such as universities, or in the case of this study, innovative SMEs.

4 Innovation by SMEs - characteristics of a SME NSI

4.1 Introduction

In this chapter the conceptual framework of the NSI approach presented in chapter 2 and 3 will be operationalised for innovation by SMEs. More specifically, we shall draft characteristics of a SME NSI and the system failures that (may) occur in this SME NSI.

The characteristics were derived on the basis of

1 a (non-exhaustive) survey of the literature on innovation by SMEs
2 a quantitative empirical analysis of innovative SMEs[1] based on various databases available at EIM.[2] Details of the analysis are included in Annex I.
3 a qualitative empirical analysis based on interviews with 10 innovative SMEs. The SMEs were selected from the 'Jonge Bedrijvenpanel' at EIM.[3]

4.2 Characteristics of a SME NSI

The survey of the literature on innovation by SMEs and the empirical analyses yielded the following characteristics of a SME NSI.

Characteristic 1: Importance of the demand side, important customers as source innovation

SMEs have a less structured way of dealing with innovation compared to large companies (Nooteboom 1993). Whereas in the larger firm, employees have the planning and implementation of innovation as their daily job, SMEs are often triggered by customer demand which leads to an ad-hoc, opportunistic innovation style (Bodewes and De Jong 2003). The ad hoc innovation style of innovative SMEs is illustrated by the following example from the interviews with innovative SMEs.

> M. produces marzipan decorations for pastry and chocolates. The range of marzipan decorations is adjusted regularly. New collections are designed each year for Easter and Christmas, but M. also made a special assortment for the wedding of Willem-Alexander and Maxima. Designs for little marzipan figures for the birth of Maxima's baby are ready. One of the strengths of the company is its ability to respond quickly to topical developments.

With regard to the use of actors in the SME NSI, this might imply that SMEs in general are more triggered by the demand side, i.e. 'market/technology pull' factors, and are less of a 'technology push' factor themselves.

[1] Innovative SMEs are defined as SMEs for which constant innovation is part of their firm strategy.

[2] 'MKB Beleidspanel' and 'Jonge Bedrijvenpanel'.

[3] See Annex II for an overview of the questions.

In general the market is a trigger for innovation. However, in the case of a conservative customer, the dependence of SMEs on the market may actually put a brake on their innovation.

W. started out as an organisation developing projects to get people on welfare back to work. A reintegration company was added 5 years ago. This company sets up trajectories to help long-term unemployed, handicapped and drug addicts get a job. The fact that local authorities are required to put work out to tender is a disadvantage of the current market situation according to the company: 'The drawback of contracting out is that price often dominates other criteria. There is less attention for quality and creativity. However, there will be no innovation if no innovative projects are put out to tender. If an idea cannot be put into practice, one cannot learn from its implementation and one cannot optimise the concept. Ministries should create space for innovation. By doing so, they can increase the market for innovative projects.'

The importance of interaction

Characteristic 2: Importance of interaction to gain access to resources (material and knowledge)

SMEs in general have material disadvantages compared to large firms. These material disadvantages consist of a lack of financial resources and difficulties in affording highly qualified employees. To be able to innovate, companies also have to access new knowledge sources that lie outside the company or even outside the existing field of knowledge (bridging structural holes). With regard to the SME NSI, this implies that an SME is more dependent on interaction with other actors. In other words, interaction in resource-rich networks might prove crucial in the SME innovation system.
On the other hand SMEs possess behavioural advantages which can be described as an entrepreneurial spirit, internal flexibility and the consequent ability to respond rapidly to changing market conditions (Rothwell 1989). To be able to acquire the necessary resources for innovation, and the firm's functioning in general, SMEs can use this flexibility and entrepreneurial spirit to access resource rich networks.

From the empirical analysis on EIM data it follows that the three main reasons for *inter-firm* partnerships are

– To reduce costs (mentioned by 36% of the respondents)
– To be more competitive (21%)
– To gain access to knowledge/exchange information (15%)

It appears that access to knowledge is an important reason for entering inter-firm partnerships. This confirms the importance of co-operation or interaction to gain access to knowledge resources (part of characteristic 2).

According to one innovative SME interviewed:
'The reason for the co-operation is that [we] lack the expert knowledge ... ourselves. Even if we did have the knowledge, we would not be able to develop the concept ourselves. This requires not only knowledge, but also mental capacity and in particular power to change things.'

If interaction is indeed important in order to gain access to resources, certainly to knowledge resources, does this also mean that companies that co-operate are more innovative?

Characteristic 3: Interaction is importance with respect to innovation
The empirical analysis indicates the following:

- SMEs that are part of one or several inter-firm partnerships are more innovative than firms that are not. In other words, co-operating SMEs more often put a new product or service on the market. Fifty-two percent of the SMEs that are part of one inter-firm partnership put a new product or service on the market. This figure is 62% in the case of SMEs that are part of several partnerships. Of the SMEs that are not part of a inter-firm partnership, 41% put a new product or service on the market.
- The same holds for SMEs that co-operate with another company, education or research organisation in the region (regional co-operation). 69% of the SMEs co-operating with a company, education or research organisation in the region have introduced new products/services on the market in the last three years. This figure is 54% in the case of SMEs that do not engage in regional co-operation.
- The same holds for SMEs that are a member of a Rotary club. We take this as an indication of 'active networkers'. Of the SMEs that are a member of a Rotary club, 82% have introduced new products/services on the market in the last three years. This figure is 57% in the case of SMEs that are 'not active networkers'.

With regard to the SME NSI we conclude that SMEs more active in co-operation or networking are more innovative.[1]

For all three kinds of co-operation (inter-firm partnerships, regional co-operation and networking) it is the case that the impact of co-operation/networking is purely on the *frequency* of innovation. Innovations of co-operating or networking SMEs are not more innovative compared to non-co-operating or networking SMEs in the sense that they are new e.g. for the sector or for the Netherlands as a whole. That is, the impact of co-operation/networking is not on the *quality* of the innovation.

We also investigated to what extent active networkers (i.e. Rotary member) will experience fewer bottlenecks in finding capital and personnel, for example. For this purpose we have crossed membership of a Rotary club with the bottlenecks that SMEs experience in growth of the company. We did not however find any evidence of this relationship.

Characteristics of innovative SME interaction

Characteristic 4: Innovative SMEs search for and find knowledge/information in innovation-related areas (product development, production methods and new materials) is in the proximity of their product or the production process.
The empirical analysis based on various databases reveals that the main channels for innovative SMEs to seek and find knowledge/information in innovation-related areas are:

- suppliers.[1] 41% of innovative SMEs use suppliers as a source of knowledge/information in the area of product development, 50% use suppliers to seek

[1] These findings correspond to a study by Poot, A.P. and Brouwer, E. (2001), *Samen innoveren: een onderzoek naar publiek-private en private kennisrelaties in Nederland*, The Hague: Ministry of Economic Affairs.

and find knowledge/information in the area of production methods, 65% use suppliers to seek and find knowledge/information in the area of new materials.
- competitors. The percentages of innovative SMEs that use competitors as a source of knowledge/information in the 3 innovation-related areas are 30%, 26% and 16%, respectively.
- sectoral organisations. The percentages of innovative SMEs that use sectoral organisations as a source of knowledge/information in the 3 areas are 28%, 19% and 21%, respectively.

Innovative SMEs seek and find information/knowledge in innovation-related areas in their own sector or the production chain. I.e. they seek and find information in the proximity of their product or production process.
Only the larger SMEs (50-99 employees) also use professional organisations such as consultancy companies.

P. offers consultancy services in the field of network safety. The company adapts products of large software companies (an Israeli company Checkpoint and a number of American firms, IBM, Cisco Systems etc.) to the market and provides tailor-made solutions if the suppliers' systems do not match. They often act as advisors themselves and provide the hardware and software. Suppliers are an important source of knowledge on innovation. They communicate a lot through the internet and employees of P. visit these companies frequently to find out about the latest developments.

Characteristic 5: Geographical proximity is less important. However, for smaller companies the region is an important dimension for seeking and finding knowledge/information in innovation-related areas and for technological co-operation.
Geographical proximity is less important for searching and finding knowledge/information in innovation-related areas. Innovative SMEs seek and find knowledge/information on product development, production methods, new materials and patents first and foremost at national level (58%, 53% and 57%, respectively). For small companies, i.e. 0-9 employees, and to some extent 10-49 employees (with respect to seeking and finding knowledge/information on production methods), the region is the second most important dimension. The percentages for companies with 0-9 employees are 34% in the case of product development, 37% in the case of production methods, and 32% in the case of new materials. In other words, for smaller companies geographical proximity is more important. Company size has an impact. Companies with 50-99 employees seek and find knowledge/information in innovation-related areas at the international level in the second instance.

With respect to the location of technological co-operation partners we find a similar pattern. On the whole, the national level is the most important. Yet, for small companies the region is also an important dimension for technological co-operation. For companies with 50-99 employees technological partners are located internationally in the second instance.

[1] The fact that suppliers constitute the main channel for searching and finding knowledge/information in innovation-related areas indicates that (innovative) SMEs are mainly technology adopters as opposed to technology developers.

Characteristic 6: Co-operation decreases with company size.
Measurements of regional co-operation show that of the innovative SMEs with 0-9 and 10-49 employees, a minority of companies co-operate with another firm, education or research organisation in the region (36% and 45% respectively). Similarly, measurements on inter-firm partnerships show that of the innovative SMEs with up to 49 employees a minority is part of such a partnership. For innovative SMEs with 0-9 employees the percentage of firms not involved in inter-firm partnerships is even higher than 75%. Of the innovative SMEs with 50-99 employees, over 50% of the companies co-operate with another firm, education or research organisation in the region or are part of one or several inter-firm partnerships.

The empirical analysis shows that co-operation decreases with company size.[1] Further empirical analysis shows that size ('we are too small') is mentioned as a reason per se for innovative SMEs not to enter inter-firm partnerships. With regard to the SME NSI this indicates that scale has an effect on co-operation by innovative SMEs.

> According to one innovative SME:
> 'For a small company, bottlenecks in co-operation are time and money. One often does not have enough time to invest in co-operation or not enough money.'

This characteristic constitutes a catch: small innovative SMEs co-operate the least, whereas it is these companies that in theory need co-operation the most in order to obtain access to material and knowledge resources.

Another important reason (following from the empirical analysis) why innovative SMEs do not enter inter-firm partnerships is that they do not see or are not aware of any value added by co-operation. This too constitutes a catch: SMEs do not see the advantages of co-operation, whereas it is these companies that in theory can benefit a lot from co-operation as a means to gain access to material and knowledge resources and as a means to raise their innovativeness.

> Among the 9 innovative SMEs we interviewed 2 entrepreneurs indicated that they do not co-operate with other companies or research institutes. The reasons given in the interviews are as follows:
> 1. Co-operation involves only the exchange of knowledge. The SME is too much of a know-it-all for joint product development.
> 2. The entrepreneur likes to do things himself as much as possible, even ICT management. If he had a choice, he would also rather do without an accountant and do this himself too.

The influence of scale and the lack of awareness of the potential benefits of co-operation might (partly) explain why, in the empirical analysis, the main reason for innovative SMEs not to enter inter-firm partnerships is that there are no partnerships in the SMEs' sector. Bottlenecks in co-operation due to scale and unawareness by some firms, can generate a lack of 'critical mass', hampering innovative SMEs that do want to co-operate.

[1] Chi-Square Tests.

Characteristic 7: Importance of intrinsic capabilities (highly educated employees, possession of e.g. patents, absorption capacity) to obtain access to high-level knowledge.

To be able to access high-level knowledge sources, the company needs a basis for coming together with other organisations. These network relationships are based upon the reciprocal exchange of information and resources. In high tech sectors, the possession of patents can often form a basis for knowledge exchange. Also, employees in these sectors are often graduates from the same universities so that it is rather easy to access external knowledge resources.

Alternatively, companies need intrinsic capacity to be able to absorb high-level knowledge. Learning is highly cumulative. The level of knowledge that a company can absorb is dependent on the level of already existing knowledge. With respect to the SME NSI, this implies that the level of knowledge that an innovative SME can access depends on the level of its intrinsic capabilities.

C. is a biotech company. It represents a case of an innovative SME with a high level of intrinsic capabilities. Everything in this company revolves around knowledge. Both researchers/entrepreneurs hold a doctor's degree. The company took out a patent for its knowledge in 1999. The company co-operates with other biotech companies in the Netherlands and abroad in the area of knowledge development. With respect to specific questions (concerning chemistry), universities also constitute a source of knowledge.

C. has sufficient intrinsic capabilities to access and absorb high-level knowledge. For companies with lower intrinsic capabilities, it might be very hard to access high-level knowledge resources and absorb knowledge.

M. hires about 7 mentally handicapped employees for its production. This is done with a certain purpose in mind. These people enjoy this work, and because they enjoy doing simple repetitive work they are good at it. The possibilities for M. to access and absorb knowledge at the scientific level will be rather limited.

The institutional framework

Characteristic 8: SMEs have inadequate recourse to the legal framework because of the cost involved. This constitutes a hard institutional failure.

Whereas transactions take place between large or small firms, the coordination task and the consequent transaction costs are the same for both types of firms. Transaction costs consist of the costs of searching a suitable partner/supplier/customer, establishing a relationship with this partner, safeguarding the transaction (e.g. by a formal contract), coordinating the transaction (e.g. project management), monitoring the execution of the agreement, haggling over the execution/prices/delivery times etc., conflict resolution, mediation or court resolution. This means that small firms have a cost-disadvantage in relation to larger firms.

As described above, setting up and safeguarding a transaction can entail considerable cost for a firm. In addition to the cost that will be an obstacle for smaller firms to properly safeguard their interactions (e.g. proprietary knowledge, material assets), the specialist knowledge required to do so may be absent. Especially when dealing with large firms (or organisations) this might prove to be a problem. Whereas a large firm will often have legal specialist knowledge 'in house', the smaller firm often does not have this knowledge and thus either has to 'buy' specialist advice that is expensive, or rely upon the large firm not to exploit its vulnerability. In cases where the firm's interests would be harmed, an SME would probably not have the time and money available to take a case to court. As a result, the SME usually has few formal means to protect itself from the potential opportunism of partner firms.

The co-operation between biotech company C. and its partners has been set down in 'material transfer agreements'. The company's knowledge is protected by a patent from 1999. This protection notwithstanding, C. is vulnerable according to the company. If a large firm is really out harm them, the company is lost. The company could afford to spend a certain amount on lawyers, but after that things would get difficult. Partly because of this, the company has opted for a non-exclusive patent. This means that everyone has access to the technology.

Characteristic 9: SMEs will have a tendency to make use of long-term relationships which increases the risk of strong network failure.

As a result of the difficulties SMEs might face in managing their interrelationships, it seems logical that they 'stick to' faithful, reliable partners to avoid transaction costs and the problems associated with safeguarding and coordinating transactions. In trusted relationships SMEs will have built up trust and habituation that make these relationships more efficient.

The director of M. has a very good personal relationship with the machine designer. The director knows this man from the time when he still owned a bakery. They develop the machines together. The director contributes the knowledge of marzipan and puts forward ideas for the operation of the machine. The machine designer contributes his knowledge of engineering and is responsible for the design and the building of the machine. As a result of the direct co-operation, the time to develop a machine is very short. A little while ago, they designed a machine for coating marzipan, making it possible to freeze marzipan. The time to develop the machine (from the start of the development to the moment at which the machine was operational) was 4.5 months.

However, as described in chapter 3, these long-term relationships carry the risk of strong network failure, i.e. myopia and inertia. The same might occur if SMEs are dependent upon large dominant partners, e.g. a large customer that has control over the small firm.

On the other hand the importance of trust and habituation entail that effective co-operation may not come about very easily. Trust has to be established. This takes time.

As one interviewee put it:
'In order to stimulate co-operation one has to start with informal diners/social evenings. People cannot be forced to co-operate.'

5 Conclusions and suggestions for further research

The NSI approach - main concepts, value added and shortcomings

The NSI approach describes innovation as an interactive, non-linear process in which actors, e.g. firms, interact with a manifold of other organisations (e.g. research institutes, customers, authorities, financial organisations). The interactions are governed by institutions (e.g. IPR, regulations, culture). This complex process, characterised by reciprocity and feedback mechanisms, determines the success of innovation. The complex of institutions and actors in a country that influences the innovation process is known as the national system of innovation.
The alternative view on innovation in the NSI literature has given way to the identification of new rationales for government intervention, the so-called system failures.

The NSI approach has two important advantages. First of all the NSI approach helps to understand how innovation evolves and what the elements and framework conditions are that determine and affect innovation and economic development. It offers a 'richer picture' of reality compared to mainstream growth models. Second (and related to the first advantage), the NSI approach offers policy makers the potential to derive more appropriate leads for government intervention in innovation.

However, the conceptual framework of the NSI approach is (necessarily) very abstract. It only offers a view on the elements and framework conditions that determine and affect innovation processes *in general*. In reality however there are numerous innovation processes. Each has its own specific (sub-)system of organisations, interactions and institutions, with its own specific causal links, determining and affecting the innovation process. Also, in these different systems different failures may occur. To get a more specific grasp of the characteristics of a NSI and the system failures that occur in this system, the conceptual framework has to be 'operationalised' at appropriate levels. In this study we have drafted characteristics of an SME NSI, including the system failures that occur in this SME NSI.

Characteristics of an SME NSI

The characteristics of an SME NSI can be summarised as follows:

1 Innovation of SMEs is often 'pulled' by the demand side. Absence of (sufficient) innovative demand may even put a brake on innovation.
2 The searching and finding by innovative SMEs of knowledge/information in innovation-related areas (product development, production methods and new materials) is in the proximity of their product or the production process. They search for and find knowledge/information in innovation-related areas in the production chain (suppliers) and sector (competitors, sector organisations). Geographical proximity is less important. However, for smaller companies the region is an important dimension for seeking and finding knowledge/information in innovation-related areas and for technological co-operation.
3 On the whole, co-operation by innovative SMEs is relatively limited. This represents a weak network failure. This may well have consequences for the effectiveness of the SME NSI with respect to innovation. In theory SMEs need co-operation the most in order to gain access to material and knowledge resources. Second, and more importantly, this study established that SMEs more active in co-operation and net-

working are more innovative. I.e. co-operation and networking entails advantages in terms of innovation.
Reasons for the weak network failure that follow from the empirical analysis are
- scale
- unawareness of companies of the value added of co-operation

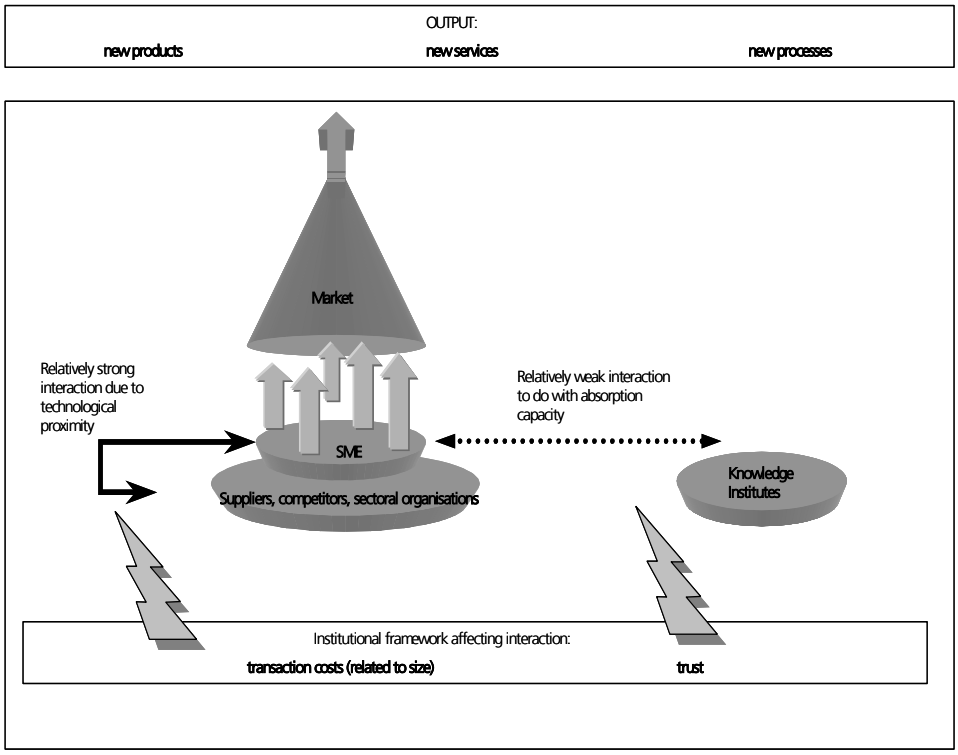
Also of consequence for co-operation are intrinsic capabilities. Companies need intrinsic capabilities to get access to high-level knowledge. For companies with lower level intrinsic capabilities it may be very hard to access high-level knowledge and absorb it. This means that not every company is capable of merely co-operating with a university. There are limits to the level of co-operation/partners that an SME can handle. The limit is determined by its intrinsic capabilities. Capabilities failure may thus be another reason for limited co-operation (weak network failure).

4 SMEs have inadequate recourse to the legal framework as a result of the costs that are involved. This constitutes a hard institutional failure.

5 Because of relatively high transaction costs and contracting disadvantages, SMEs will have a tendency to make use of long-term, reliable relationships. However, this increases the risk of strong network failures, i.e. myopia and inertia.

The main characteristics of a SME-NSI are summarised in figure 4.1.

Figure 4.1 Characteristics of a SME-NSI



Source: EIM, 2003.

Leads for SME innovation policy

As mentioned earlier the NSI approach offers policy makers the potential to derive more appropriate leads for government intervention in innovation. The characteristics of the SME NSI, i.e. the system failures identified above, provide leads for a specific SME innovation policy.

The dependence of SMEs on market pull with respect to innovation implies that there should be sufficient *innovative* demand. This applies not only to the private market but also to the government (as illustrated by one case in this study).

On the whole, co-operation by innovative SMEs is relatively limited. The causes identified in this study are scale and awareness. An SME innovation policy should then be aimed at facilitating co-operation for the smallest (0-49 employees) and increasing the awareness of companies of the benefits of co-operation.
At the same time, however, there are limits to a policy aimed at stimulating co-operation. There are limits to the level of co-operation/partners that an SME can handle. The limit is determined by its intrinsic capabilities. This implies that there are 'natural' boundaries to industry-university co-operation. Innovation policy should take this into account.

SMEs have inadequate recourse to the legal framework as a result of the costs that are involved. SMEs would benefit from an efficient regulatory framework. Cheap courts with fast procedures could considerably benefit a small firm's potential to compete in the 'large player's world'. Other options are the development of 'communities of practice' that prescribe the rules of the game to which the companies should adhere or the development of own regulation, e.g. by means of improvised informal courts, mediation by third parties etc. However, these functions will work well only in cases with more or less equal parties and strong network relationships. In terms of an SME NSI, this would refer to the informal institutions.

Dependence of SMEs on long-term, reliable relationships increases the risk of strong network failures, i.e. myopia and inertia. This would indicate that much attention has to be paid to 'keeping SMEs awake' so that they are eager to keep up to date with new partners, developments, technologies etc. Intermediaries and brokerage events may play an important role in achieving this.

Suggestions for further research

The characterisation of an SME NSI drafted in this paper has a preliminary character. The main aim of this study was to add to the understanding of the NSI approach. Describing an SME NSI and the system failures therein first and foremost served as an operationalisation of the conceptual framework of the NSI approach. Yet, particularly with respect to formulating solid leads for innovation policy, the characteristics of a SME NSI need to be corroborated, deepened and extended by additional research.

It should be noted that, in our quantitative empirical analysis we have taken innovative SMEs as a more or less homogeneous group. In reality, however, this is a diverse group. The SME NSI might be different for different types of SMEs. Drawing the characteristics of SME NSIs for different kinds of SMEs may be a topic for further research.

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Annex I Data bases used in empirical analysis

The SME policy panel (MKB-beleidspanel)

Since 1997 EIM has been using the so-called SME policy panel to gather information that is of common interest and for which there is insufficient market demand. The panel addresses the need to collect unique primary information, lacking in the SME knowledge infrastructure.

The SME policy panel offers two types of data:

– Basic information on the characteristics of companies. This includes information that respondents can be asked about directly, like e.g. the number of employees. Given the short-term character of this information (e.g. revenue changes every year), it is registered on an annual basis. Basic information also includes information that is more difficult to come by and that needs to be obtained in a more indirect way, like the degree of innovativeness, for example. This last category of data is renewed every two years by way of a written questionnaire that in principle contains the same questions each time.
– Policy related information. This includes mainly performance, attitude and behaviour of the company. The information is gathered by telephone. Members of the panel are contacted 3-4 times a year. Each telephone survey takes approximately 15 minutes and covers 2-3 policy themes.

The (stratified) sample for the SME policy panel deliberately matches the nine (main) sectors in the EIM Business Information System (BLISS). This permits re-weighing results from the panel and comparing them to other data available in BLISS (e.g. employment and level of investment). The sample is based on three size categories of SMEs and nine sectors in which the companies operate.

The nine sectors are:

– Manufacturing
– Building and civil engineering
– Distributive trades/repair of consumer goods
– Hotels and catering
– Transport, storage and communication
– Letting of real estate
– Vbanking and finance
– Other services
– Non-private business

In addition to this classification, the panel also distinguishes size categories:

– 0-10 employees
– 10-50 employees
– 50-100 employees

In order to be able to draw valid conclusions from the data of a sample, it is vital that there are sufficient observations in each subset[1]. It has been attempted to have about 110 firms in each subset, ideally resulting in approximately 3000 firms on the panel.

[1] The combination of the three size categories and the nine sectors gives 27 subsets.

An important characteristic of the panel is that developments in time can be monitored (longitudinal research). It is important to note that some turnover will occur: entrepreneurs cannot or do not wish to be on the panel anyway and hence stop. Entrepreneurs that have stopped are replaced - as far as possible - by other firms in the same subset.

The Start-ups panel (Jongebedrijvenpanel)

The start-ups panel was launched in 1994. In those days the panel consisted of about 2,000 entrepreneurs that had set up their own company in the first half of that year. At present, the panel consists of over 600 operational entrepreneurs in different sectors. The panel is contacted once a year. Up to a few years ago, this was done through a written survey. Nowadays this is done by telephone which makes it possible to obtain more opinions and assessments from these young companies concerning certain topics. Each measurement contains 'general' questions about the state of affairs in the company (revenue, employment, profits) and questions concerning a specific topic (e.g. growth process or investment behaviour).

Annex II Checklist for face-to-face interviews

Blok 'The SME' - beschrijving van de innovatieve MKB-bedrijven
- type innovatieve MKB bedrijf (beschrijving bedrijf)
- innovatie
  - wat doen ze (product, dienst of proces)?
  - hoe doen ze dat (eigen R&D, ...)?
  - welke factoren binnen de organisatie hebben invloed op de innovatie van de innovatieve SME?

Blok 'Embeddedness' - de positie van innovatieve SMEs in het nationale innovatiesysteem
- waar zoekt/vindt innovatieve SME kennis en/of informatie op het gebied van innovatie?
- welke knelpunten doen zich voor bij het zoeken/vinden van kennis en/of informatie op het gebied van innovatie?
- werkt de innovatieve SME samen op het gebied van innovatie?
  Indien ja:
  - met andere bedrijven?
  - wat zijn dat voor bedrijven (Soort:toeleveranciers, afnemers, klanten? Grootte:groot, klein? Terrein: op andere (technologie-)gebieden, aanverwante? Locatie: in de regio, nationaal of internationaal?)
  - met kennisinstellingen?

  Indien nee:
  - waarom niet? Redenen (controleer of het bewuste keuze is of dat er bottlenecks zijn)?
  - zou de innovatieve SME wel willen samenwerken?
  - Indien ja:
    - waarom?
    - wat belemmert de innovatieve SME in het aangaan van samenwerking
- maakt de innovatieve SME deel uit van een ondernemersnetwerk (breder dan alleen op het gebied van innovatie)?
  Indien ja:
  - wat voor soort netwerk is dit (van andere bedrijven in de branche, Rotary Club, sportclub, anders te weten: ...)
  - wat zijn de redenen om lid te zijn van zo'n netwerk
  - welke heeft deelname aan het netwerk op uw bedrijfsvoering? (Vaardigheden, toegang tot kapitaal/personeel/..., anders te weten)

Blok 'Interaction' - kenmerken van samenwerking door innovatieve SMEs
- wat zijn de redenen om het samenwerkingsverband aan te gaan?
- wat is de aard van het samenwerkingsverband (gericht op welke activiteiten: R&D, marketing, product(ie), ...)?
- Hoe lopen de kennisstromen in het samenwerkingsverband? *Doel is om de positie (bron, bestemming, intermediair) van de innovatieve SME in het samenwerkingsverband te bepalen.*
- waar loopt u als klein bedrijf tegenaan bij samenwerking (knelpunten)? *Doel is om te bepalen of samenwerken moeilijk (duur, veel inspanning) is, wat erbij komt kijken(hoe de zaken geregeld zijn (afspraken op papier of informeel)), of omvang van de SME een rol speelt, anders te weten: ...*

– Indien aan de orde: wat zou er volgens de innovatieve SME moeten gebeuren om samenwerking te stimuleren en effectiever te laten verlopen?

Blok 'Institutions' - welke randvoorwaarden/omgevingsfactoren hebben invloed op innovatie door innovatieve SMEs

– welke factoren zijn van invloed op uw innovatie-activiteiten
  - financiële randvoorwaarden (doorvragen: waarom is 'geld' een issue?)
  - wet- en regelgeving, inclusief octooien
  - andere randvoorwaarden (bijvoorbeeld scholing)?
  - wat zou er volgens de innovatieve SME moeten gebeuren om zijn innovatie-activiteiten te stimuleren en effectiever te laten verlopen?

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